 Nowa Stomatol 2015; 20(4): 133-141 DOI: 10.5604/14266911.1188962

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Influence of socioeconomic and nutritional factors on the development of early childhood caries in children aged 1-6 years

Wpływ czynników socjoekonomicznych i żywieniowych na rozwój próchnicy wczesnej u dzieci w wieku 1-6 lat

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Keywords

early childhood caries, socioeconomic status, feeding practice

Summary

Introduction. The high incidence of early childhood caries (ECC) highlights the need to analyze the causes.
Aim. Evaluation of the impact of diet and socioeconomic conditions on the risk of ECC development in children.
Material and methods. A group of 686 pediatric patients aged 1-6 from the University Dental Clinic in Krakow was examined for caries. The parents were asked to complete a questionnaire on the eating habits of children and on the sociodemographic factors.
Results. Children aged 1-2 from rural areas and average education of parents constituted a significant factor affecting the intensity of ECC. Consumption of sugary foods at night increased the occurrence of caries by more than 3.5 times in 1–2-year-olds, and by 4 times in 5-year-olds. Frequent consumption of fruit juices and carbonated beverages had a significant impact on the occurrence of caries in 6-year-olds.
Conclusions. Dietary pattern is a major cause of ECC. The relationship between ECC and the place of residence, low parental education and poor economic status indicates the target group for intensive educational activities for the prevention of dental caries.

Introduction

The current definition of early childhood caries (ECC), proposed in 2013 by the World Health Organization and the American Dental Association, states it to be a pathological process of extracorporeal origin, which leads to decalcification and proteolytic degradation of the dental hard tissues. ECC is defined as the presence of one or more decayed, missing due to caries, or filled teeth in children less than 6 years of age (exactly up to 71 months, i.e. 5 years and 11 months). Also, this is a multistep and multifactorial disease, which occurs because of the following causes:

- behavioral, psychosocial, and genetic factors,
- specific interactions occurring between microorganisms and the host,
- biochemical changes in the oral cavity, such as the metabolism of sugars from food to acids which decreases pH of the environment leading to enamel demineralization and formation of carious lesion.

Currently, in countries with a high prevalence of caries, the fundamental problem is the low value given in health care services toward prevention of diseases of the oral cavity. In Denmark, Germany, and Norway (where in 2013, the frequency of caries was estimated to be 24, 28.6 and 11%, respectively), health care services directed toward prevention/treatment are distributed on a 1:1 scale (1, 2) and in Poland, financing of services aimed at prevention in the aspect of health of the oral cavity is transient (3). Hence, Poland is in the forefront of countries with the highest proportion of children with caries: 84% among the compared European countries (4).

ECC is a serious health problem worldwide. Societies of the so-called Third World, developing, as well as the highly developed countries face this problem.

Numerous studies have been conducted to determine the causes of occurrence of ECC and the factors that increase the risk of its occurrence. Most of these studies focused primarily on the impact of nutritional eating habits of children and their families on the occurrence of ECC. Socioeconomic factors such as income, lifestyle, and availability of health care have an equally significant impact on the risk of ECC development. In this study, particular attention was paid to the consumption of carbonated beverages, snacking on sugary foods at night, and the methods of infant feeding. Furthermore, among the socioeconomic factors, place of residence, parents' education, and material condition of the families were subjected to analysis.

Aim

Aim of our study was the evaluation of the impact of diet and socioeconomic conditions on the risk of ECC development in children.

Material and methods

This study was conducted between 2010 and 2013 and included 686 pediatric patients (clinical evaluation) and their legal guardians (interview) from the Department of Pediatric Dentistry, the University Dental Clinic in Krakow, Poland. Before analyzing the results, the study group was divided into four age categories (90: 1–2-year-olds, 291: 3–4-year-olds, 138: 5-year-olds, and 167: 6-year-olds). In a clinical evaluation of patients with oral cavities, the presence of tooth decay in deciduous and permanent teeth (d/D), number of teeth removed due to caries (m/M), and number of filled teeth (f/F) were assessed. This study describes the indexes of caries (dmf/DMF) and caries prevalence, and was conducted following the criteria established by the World Health Organization for the diagnosis of ECC (5) and the International Caries Detection and Assessment System (ICDAS) II (6) ((d/D) was considered to be ≥ 3 in ICDAS II) under artificial lighting using a dental mirror (Kavo Lux 1415, Germany) and a periodontal probe (WHO LM 8-550 B XSI, LM, USA). ECC was dichotomized as absent or present. The examiners used appropriate equipment to protect against individual cross-infection, with all necessary instruments and materials being packed and sterilized. The DMF index (D – decayed; M – missing; F – filled teeth) for permanent teeth and the dmf index (d – decayed; m – missing; f – filled teeth) for primary teeth because of dental caries were calculated.

This study was conducted by qualified dentists (internal examiners) with many years of experience in epidemiological studies of the oral cavity. One team consisting of six researchers (two examiners and four assistants) was installed at each health care unit (Department of Pediatric Dentistry, Medical University of Warsaw and Department of Pediatric Dentistry, Institute of Dentistry, Jagiellonian University Medical College in Krakow). Prior to the clinical work, the examiners underwent a calibration and training exercise for the diagnosis of ECC and DDE (diffuse opacity, demarcated opacity, and enamel hypoplasia) based on standards developed by the American Academy of Pediatric Dentistry, 2014 (7-11).

The calibration exercise consisted of three stages. The theoretical stage involved a discussion of the criteria for the diagnosis of DDE (12) and ECC and the participants analyzed case studies and an oral clinical examination (OCE) to demonstrate their proficiency in diagnosis, treatment planning, and clinical care. A specialist in pediatric dentistry was the mentor and partner in the theoretical framework and coordinated this step, instructing 10 general dentists on how to perform the examination. An analysis of photographs was performed on two separate occasions with a 2-week interval between sessions. Data analysis involved the calculation of Kappa coefficients for both inter-examiner and intra-examiner agreement. The Kappa coefficient was set at 0.92 in the pilot studies, which indicates the internal examiner's reliability. As the

Kappa coefficients were very good, the examiners were considered capable of conducting the epidemiological study.

After clinical evaluation, the children or their legal guardians answered a few questions prepared in accordance with the closed questions in the questionnaire. The first part of the questionnaire was related to their sociodemographic profile and consisted of three closed questions (material status, parents' education, place of residence), while the second part was related to the children's dietary habits (frequent consumption of fruit juices and carbonated drinks, snacking on sweetened foods at night, type of feeding: natural/artificial/mixed, etc.).

The data were collected from the questionnaire (Appendix 1) and subjected to statistical analysis.

Statistical analysis

A data set was analyzed using SPSS version 12. Data were presented as frequencies in percentage and were analyzed using the chi-square test, where the *p*-values were considered significant at $p < 0.05$. The type of correlation between different variables and the ECC was evaluated using Karl Pearson correlation. To measure the impact of possible risk factors of childhood caries, multiple logistic regression was used for which the odds ratio (OR) was calculated for selected factors of the ECC development. The results of logistic regression are summarized in table 1.

Ethical approval

Consents were obtained from all patients and the study procedure was approved by the Bioethical Committee of the Jagiellonian University in Krakow (No. KBET/194/B/2011).

Results

Caries prevalence

The prevalence of caries in the investigated population was observed to be 66%. The highest proportion of children affected with caries was observed in the group of 5-year-olds (72%), while the lowest was in the group of 1–2-year-olds (59%) (tab. 2).

Table 1. Influence of particular variables on the incidence of caries in different age groups (logistic regression).

Age group		Feeding			Snack of sweetened foods at night	Frequent consumption of fruit juices and carbonated drinks	Toothpaste for children
		Natural	Artificial	Mixed			
1–2	OR	Reference value	1.849	2.454	3.684	2.602	4.71
	95% Confidence interval for OR		0.436	0.436	1.174	0.774	0.447
			7.845	13.813	11.565	8.744	49.628
	Level of significance		0.405	0.309	0.025	0.122	0.197
3–4	OR	Reference value	1.002	1.813	1.427	2.227	0.287
	95% Confidence interval for OR		0.445	0.669	0.826	1.252	0.033
			2.258	4.916	2.466	3.961	2.46
	Level of significance		0.995	0.242	0.203	0.006	0.006
5	OR	Reference value	0.773	1.029	3.843	2.136	0.702
	95% Confidence interval for OR		0.195	0.28	1.411	0.838	0.164
			3.06	3.787	10.466	5.443	2.996
	Level of significance		0.713	0.966	0.008	0.112	0.632
6	OR	Reference value	0.647	5.449	1.177	2.251	1.041
	95% Confidence interval for OR		0.239	0.665	0.542	1.031	0.351
			1.754	44.615	2.556	4.917	3.093
	Level of significance		0.392	0.114	0.681	0.042	0.942

Logistic regression – statistical method which allows calculation of OR for selected factors (called explanatory variables)
Odds ratio (OR) – describes the odd of an event occuring in the study group compared to the control group

Table 2. The prevalence of caries in different age group of children from Kraków and surrounding areas.

Age	1-2		3-4		5		6		All groups	
	n	%	n	%	n	%	n	%	n	%
Absence of caries	37	41	97	33	39	28	57	34	230	34
Caries	53	59	194	67	99	72	110	66	456	66

In the group of 5-year-olds, the index of intensity for primary teeth was dmf score = 4.35 ± 3.62, while in the group of 1–2-year-olds, it was dmf score = 4.14 ± 4.52, wherein this number mainly constituted the number of teeth affected by active caries ($p < 0.001$) (tab. 3).

Relationship between the obtained results on the intensity of caries in particular age groups and the place of residence showed higher frequency of caries in the group of 1–2-year-olds living in rural areas compared to children living in urban areas ($p = 0.026$; chi-square test), and in children of parents with secondary education compared to children of parents with higher education ($p = 0.002$; chi-square test). In the group of 5-year-olds, the prevalence of caries was independent of the place of residence. In the group of 6-year-olds, the highest prevalence of caries was reported in children living in rural areas when compared to children living in urban areas ($p = 0.005$; chi-square test) (tab. 4).

In children from poor and low-income families, the prevalence of caries was higher compared to children from high-income families ($p = 0.044$; chi-square test). Similarly, in the groups of 1–2-year-olds, 3–4-year-olds, 5-year-olds, and 6-year-olds, parents' education had the highest impact on the prevalence of caries. In children of parents with vocational and secondary education, a higher frequency of caries was reported compared to children of parents with higher education ($p < 0.001$; chi-square test) (tab. 4).

In the group of 1–2-year-olds, intake of sweetened foods or beverages at night had a significant impact on the occurrence of caries. This factor increased the occurrence of caries over 3.5 times (OR = 3.684). Moreover, frequent consumption of fruit juices and carbonated beverages increased the risk of ECC over 2.5 times (OR = 2.602). Among the group of 3–4-year-olds, frequent consumption of fruit juices and carbonated beverages increased the odds of developing dental caries more than twofold (OR = 2.227) (tab. 1) compared to sporadic consumption.

The influence of mixed feeding (OR = 1.813) and snacking on sweets at night (OR = 1.427) on the risk of caries development was reported to be statistically insignificant. Snacking on sweets at night had a significant impact on the occurrence of caries in 5-year-olds (OR = 3.843), which therefore increased the odds of caries occurrence by almost 4 times. The impact of other variables was statistically insignificant. In the group of 6-year-olds, frequent consumption of fruit juices and sweetened beverages had a significant impact on the occurrence of caries. This factor increased the risk of ECC more than twofold. In contrast, mixed feeding (OR = 5.449) and snacking on sweetened foods at night (OR = 1.177) were statistically insignificant (tab. 1).

Discussion

The results obtained in this study on the development of ECC in children from Krakow and surrounding areas were compared with those of studies conducted in, among others, South Africa, North and South America, Australia, South-East Asia, and Europe. On comparing data on the prevalence of caries in children from Krakow to the situation in Europe or South America, one's attention is drawn to the scale of the problem-as Krakow with a frequency of 66% ranks first preceding Czech Republic (13) and Brazil (14).

In the group of 1–2-year-olds, the prevalence of caries was estimated at 59% (tab. 2). Our results are in accordance with those obtained by Retnakumari and Cy-

Table 3. Prevalence and intensity of caries measured with average dmf score for primary teeth and average DMF score for permanent teeth in particular age groups.

Age group	d		m		f		dmf		D		M		F		DMF	
	m	SD	m	SD	m	SD	m	SD	m	SD	m	SD	m	SD	m	SD
1–2	3.94	4.54	0.12	0.54	0.08	0.52	4.14	4.52	0	0	0	0	0	0	0	0
3–4	3.58	4.08	0.27	1.08	0.25	0.73	4.1	4.28	0	0	0	0	0	0	0	0
5	3.3	3.39	0.49	1.35	0.56	1.05	4.35	3.62	0.06	0.34	0	0	0.01	0.17	0.07	0.38
6	2.66	3.15	1.42	2.37	0.6	1.05	4.68	3.89	0.27	0.87	0	0	0.13	0.62	0.4	1.06

m – average, SD – standard deviation, p – analysis of variance (ANOVA)

Table 4. Influence of socioeconomic factors on the incidence of caries in different age groups.

Age group		Place of residence						Material status						Parents' education					
		Big city		Small city		Countryside		Good		Average		Poor		Primary		Secondary		Higher	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
1–2	Absence of caries	21	42.86	9	69.23	7	25	30	42.25	6	33.33	–	–	0	0	10	27.78	27	57.45
	Caries	28	57.14	4	30.77	21	75	41	57.75	12	66.67	–	–	7	100	26	72.22	20	42.55
	p	0.026						0.491						0.002					
3–4	Absence of caries	62	38.99	11	28.21	24	25.81	83	35.78	13	23.64	–	–	6	17.14	20	22.47	71	43.56
	Caries	97	61.01	28	71.79	69	74.19	149	64.22	42	76.36	–	–	29	82.86	69	77.53	92	56.44
	p	0.077						0.086						<0.001					
5	Absence of caries	20	26.32	9	37.5	10	26.32	31	27.43	7	30.43	0	0	3	23.08	6	12.5	30	40
	Caries	56	73.68	15	62.5	28	73.68	82	72.57	16	69.57	1	100	10	76.92	42	87.5	45	60
	p	0.542						0.79						0.004					
6	Absence of caries	44	43.56	6	25	7	16.67	52	38.81	5	16.13	0	0	2	7.69	7	15.22	48	50.53
	Caries	57	56.44	18	75	35	83.33	82	61.19	26	83.87	1	100	24	92.31	39	84.78	47	49.47
	p	0.005						0.044						< 0.001					

p values – obtained from chi-square test
Chi-square test – used to evaluate whether two qualitative variables are independent of each other. A p-value below 0.05 indicates the presence of a relationship between variables
Qualitative variables – variables for which several values are assigned (e.g., gender: woman/man). Answer to the single choice question (A/B/C). Opinion about the product (pretty/ugly/no opinion). Age divided into different categories (up to 20 years/21–30 years/31–40 years/above 40 years)

riac (15) in India. The highest score in this age group was observed by Majorana et al. (16) in Italy, where the prevalence of caries was observed to be 80.84%. The index of caries (dmf) in the group of 1–2-year-olds from Krakow was 4.14 ± 4.52 (tab. 3), which was more than twofold higher than that obtained by Kumarihamy et al. (17), who achieved the dmf index at the level of 2.01, which is 4 times higher than the indexes obtained by Zhou et al. (18) whose dmf index was 0.04 ± 0.4 in children of 20 months.

Among the group of 3–4-year-olds from Krakow and surrounding areas, the prevalence of caries was observed to be 66.67% (tab. 2), which is one of the highest scores in this age group. Similar frequency was observed by Sankeshwari et al. in India in 4-year-olds (66.46%) (19). Krakow was preceded only by China (20) with the prevalence of caries among 4-year-olds estimated at 71.7. The dmf index for children aged 3–4 years from Krakow was 4.1 ± 4.28 (tab. 3), while a group led by Li et al. (20) obtained dmf indexes estimated at 3.06 ± 4.12 and 4.58 ± 4.6314, respectively, for 3- and 4-year-olds. Compared to the results of children from Krakow and surrounding areas, the results obtained by Corrêa-Faria et al. (21) in Brazil show a slightly decreased prevalence of caries – 44.3% in 3-year-olds and 50.9% in 4-year-olds. The lowest prevalence of caries estimated at 29.1% was described by Naidu et al. (22) in central Trinidad.

In the group of 5-year-olds from Krakow, the prevalence of caries was 72% (tab. 2). Also, in this age group, Krakow was among the leaders just behind China (21) where the prevalence of caries in 5-year-olds was 78.3%. The lowest score of caries in this age group (28.6%) was reported by Congiu et al. (23) in Italy. Among 5-year-olds from Krakow and surrounding areas, the index of caries intensity was estimated at 4.35 ± 3.62 (tab. 3). Chu et al. (24) describe the dmf index to be almost twofold lower in Hong Kong (2.3 ± 3.6). Higher index of caries, compared to that obtained among 5-year-old children from Krakow (5.54 ± 4.97), was observed by Li et al. in China (20).

In the group of 6-year-olds, the prevalence of caries was 66% (tab. 2). Comparable frequency estimated at 64% was described by Chu et al. (24) in Hong Kong. The dmf index for children from Krakow was reported to be the highest among the data found in the source work in this age group (tab. 3). In the study conducted by Chu et al. (24), the dmf index was 2.6 ± 3.3, whereas in the study led by Peres et al. (25) the value was 3.29, and 46.6% of children were characterized by a dmf score ≥ 4.

Among the socioeconomic factors investigated, for 1–2-year-olds, the place of residence and parents' educational level were statistically significant (tab. 4). Children living in rural areas more often suffered from caries (75%) compared to children from small (30.77%) and large cities (57.14%). Similar conclusions were drawn from the study conducted by Corrêa-Faria et al. (21).

Low level of education of parents showed a positive correlation with the occurrence of ECC in the group of 1–2-year-olds. The prevalence of caries in children whose parents had vocational and secondary education was 100% and 72.22%, respectively (tab. 4). Similarly, in the study by Congiu et al. (23) low level of education of parents negatively affected oral cavity health of children. In studies conducted by Zhou et al. (18) and Prakash et al. (26) attention was paid only to the mothers' education. It was proven that the ECC occurred more frequently among children whose mothers had no education or had primary education.

In a study involving children of ages 1–2 years from Krakow and surrounding areas, material status of parents was a nonsignificant risk factor for ECC development ($p = 0.491$) (tab. 4). In contrast, studies conducted by Prakash et al. (26) showed that in the group of 1–2-year-olds, ECC occurred more frequently among children from low-income families compared to the children from high-income families.

In the group of 3–4-year-olds as well as 5-year-olds from Krakow and surrounding areas, parents' education had a statistically significant impact on the development of ECC (tab. 4). In the group of 3–4-year-olds, more than 80% of children of parents with vocational education showed symptoms of ECC. Similar results were obtained from studies conducted by Li et al. (20) and Chu et al. (24) in China.

The influence of place of residence and the economic status of the family was inconsistent when considering the health of the oral cavity in 3–4-year-olds and 5-year-olds (tab. 4). In the studies conducted by Corrêa-Faria et al. (21) and Li et al. (20) it can be observed that the majority of children living in rural areas exhibit symptoms of caries.

In southern Africa, Postma et al. (27) reported the highest dmf indexes in children of middle-income families. A study conducted among African Americans by Ismail et al. (28) showed a statistically significant effect of poor urban neighborhoods on ECC development. However, in central Trinidad, Naidu et al. (22) showed no statistically significant association between socioeconomic factors and the prevalence of caries among children.

Among 6-year-olds from Krakow and surrounding areas, the place of residence and parental education had a significant impact on the development of ECC. Over 80% of children living in rural areas showed carious lesions. In the group of 6-year-olds from Krakow, ECC was found in over 90% of children of parents with vocational education and in 85% of children of parents with secondary education. Significant impact of parents' education or exclusively mother's on the risk of caries development in this age group was also confirmed by Peres et al. (25) in Brazil and Chu et al. (24) in China.

In this study, in the group of 6-year-olds, no correlation between the presence of ECC and the material status of

families was found (tab. 4). In contrast, studies by Chu et al. (24) allow us to note that children from low-income families more frequently showed the presence of dental caries than children from high-income families. In Brazil, Peres et al. (25) have established that over 50% of children from low-income families had dmf index > 4.

An analysis of children's eating habits from Krakow and surrounding areas has shown that in a group of 1–2-year-olds, intake of sweetened foods and beverages at night had a significant impact on the occurrence of caries ($p = 0.025$) (tab. 1). In the same age group, similar correlation was also investigated in Sri Lanka (17); however, it was statistically insignificant.

The influence of this factor in older children (3–5 years) was also analyzed in Sri Lanka (17), where it was established that 52% of children with caries were fed at night, and among the children who were not fed at night, caries was reported in only 29% of them. In turn, in studies conducted in China in 2011 (20), it was found that 75.2% of investigated children (3–5 years) snacked at night. In the remaining age groups of the population studied, this factor was statistically insignificant. In the group of 5-year-olds, snacking sweetened foods at night raised the odds of ECC occurrence almost by 4 times (OR = 3.843) (tab. 1). The consumption of fruit juices and carbonated beverages was another investigated factor associated with nutritional habits. In children from Krakow and surrounding areas, a significant increase in the odds of caries occurrence was observed in the following age groups: 3–4-year-olds (OR = 2.227) and 6-year-olds (OR = 2.251) (tab. 1). In a similar study (in a group of 3–5-year-olds) conducted in Iowa, USA, statistical significance of this factor (OR = 1.34) was also demonstrated (29). In China consumption of this type of beverage more frequently than 3 times a week was adopted as the cutoff point, and this age group included 81.1% of children with caries (20, 30).

The studies by Ismail et al. (28) among African Americans in the United States, Marshal et al. (31) in the United States, and Thitasomakul et al. (32) in Asia confirmed the statistical significance of the consumption of carbonated beverages on the development of ECC. In the studies conducted in Italy (16), it was found that the intake of sweetened beverages ≥ 2 times a day significantly increases the odds of the development of ECC (OR = 1.18) in children aged 2–3 years. Studies involving the population of children from Krakow and surrounding areas showed no significant effect of frequent consumption of fruit juices and carbonated beverages on the risk of caries development in 1–2-year-olds (OR = 2.602; $p = 0.122$) and 5-year-olds (OR = 2.136; $p = 0.112$) (tab. 1).

To some extent, a kind of compilation of these two factors was considered in Łódź, Poland (33). There, the effect of consumption of beverages at night, other than mineral water or boiled water from the tap, on the risk of the ECC in 3-year-olds was analyzed. In the group consuming such beverages at night, one found more than 62% of the studied population having caries. It was found that this factor increases the risk of the ECC by 4 times in children (OR = 4.0; $p < 0.001$). Moreover, children falling asleep of children with a bottle in their mouths appeared to be an important factor in this study (32.1%, OR = 7.65; $p < 0.01$).

Another frequently studied factor which may predispose to the development of ECC is the feeding method (natural – breastfeeding/breast milk, artificial – a bottle, and mixed – a combination of the two above-mentioned options). A study conducted in Italy (9) showed statistical significance ($p < 0.01$) in terms of the influence of the type of food administered on the occurrence and development of ECC in children up to 30 months of age. It was showed that among children who were fed only artificially, over 99% were diagnosed with caries, mostly medium-advanced or advanced, whereas in children fed with 100% breast milk, this proportion was 59.18% (all cases were classified as an early form of caries, without affecting the dentin).

In the group of children who were subjected to mixed feeding, caries was diagnosed in approximately 80%, for which the level of advancement correlated with the proportion of artificial food, supplemented by breastfeeding. Similarly, mixed feeding was a statistically significant factor for the occurrence and development of caries in the study by Retnakumari and Cyriac (15) in Kerala, India. However, in the study by Prakash et al. (26) in Bangalore, India, which was conducted at the same time, the feeding method was proved to be nonsignificant, which is in agreement with the results from Krakow.

Acknowledgements

The authors would like to thank Assoc. Prof. Jolanta Pytko-Polonczyk, MD, PhD, Head of the Department of Integrated Dentistry, Institute of Dentistry, Jagiellonian University Medical College, Krakow, Poland, for her professional guidance.

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nadesłano: 09.10.2015
zaakceptowano do druku: 03.11.2015